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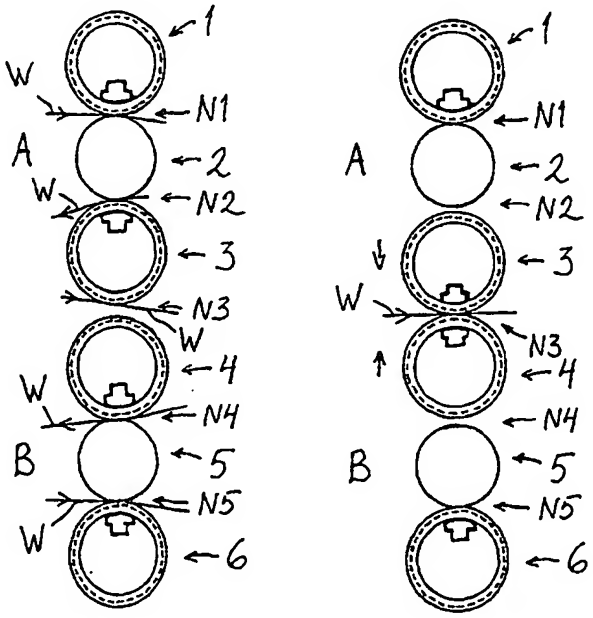
(54) Title: CALENDER



(57) Abstract: The calender contains two permanently or provisionally separate stacks (A, B) of three rolls. In each stack there is an upper roll (1; 4) and a lower roll (3; 6) upper roll (4), and a centre roll (2; 5) in nip contact with the upper roll and the lower roll. Said upper and lower rolls are mounted in a fixed position on the frame (R) of the calender in such a manner that their shells can be moved in the direction of the stack of rolls with respect to the supports (9) of the rolls. The rolls can in this way be detached from the nip contact with the centre roll. The upper and the lower roll (1, 3, 4, 6) in both stacks of rolls are soft-faced rolls and the centre rolls (2, 5) are hard thermo rolls.

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Calender

The invention relates to calender which is of the type presented in the preamble of the appended claim 1.

In multi-nip calenders a paper web is calendered by passing the web via nips between calender rolls which are arranged on top of each other to form a stack of rolls. The rolls are mounted on the frame of the calender, and they are arranged in nip contact with each other so that it is possible to calender the paper web by passing it via the nips and by arranging a predetermined load between the rolls to bring about a linear load in the nip. For example the Finnish patent 95062 and the corresponding US patent 5590593 disclose a calender, in which the two lowermost rolls in a stack composed of four rolls are variable crown rolls, advantageously zone-controlled rolls with a fixed installation, i.e. their bearing housings are suspended on supports mounted rigidly on the frame of the calender. The two uppermost rolls of which the topmost one is also a variable- crown, advantageously zone-controlled roll, are arranged movable in such a manner that their bearing housings are attached to loading levers journalled pivotable in the frame of the calender. The uppermost variable-crown roll may be equipped with a resilient coating, and the roll therebelow is a heated roll, a so-called thermo roll. The lowermost variable crown roll in the stack may also be equipped with a resilient coating. It is possible to use alternative running methods in the calender, for example, the paper web to be calendered can be passed through all three nips when the nips are closed, or when the upper nips are opened, through only two nips or one nip. As for the advantages, it is mentioned that by means of the calender it is possible to attain all the advantages which can be attained by conventional soft calenders, and in addition, the middle nip is a hard nip, by means of which it is possible to equalize the caliper. The variability of the calender also makes it suitable for many paper grades.

Corresponding variable calenders are also disclosed in the European application publication 890676 and in the GB application publication 2119422. The European application publication 890676 discloses a

calender, in which six rolls are attached to the frame to form a stack of calender rolls. The uppermost roll is mounted in a fixed position on the frame, the intermediate rolls are fixed to loading arms, and the lowermost roll is arranged to a carriage, which can be transferred vertically along a guide. The uppermost roll and the lowermost roll are variable crown rolls, and the uppermost roll and the lowermost roll and the two rolls right in the middle are equipped with an elastic coating, whereas the roll above the lowermost roll and the roll below the uppermost roll are hard-faced rolls. It is typical for the calender that when the uppermost nip and the lowermost nip are closed, the other nips therebetween are open, wherein the web can be calendered symmetrically by means of the uppermost nip and the lowermost nip, and the remaining nips can be bypassed.

The application publication GB 2119422, in turn, discloses an arrangement in which two stacks composed of three rolls are positioned side by side in the same calender frame, the middle roll in each stack being a hard roll which is mounted in a fixed position on the frame, and the soft-faced rolls on both sides of said roll can be moved to a working position into a nip contact with the hard-faced roll, and away from the same. The rolls located above and below the hard roll in both stacks are variable-crown rolls. One of the soft-faced rolls in both stacks of rolls only functions as a spare roll, which can be taken in use when the actual soft-faced roll which is in nip contact is for example damaged, and thus, in practice, the calender functions as a two-nip calender formed by two pairs of rolls.

In the US patent 4332191 Figs. 5D and 5E show a calender with two superimposed stacks of three rolls, wherein in the upper stack the middle roll is a soft roll, and in the lower stack all rolls are hard rolls. Furthermore, on the other side of the frame of the calender, there is a stack of three rolls, in which the middle roll is soft. The web can be calendered by passing it via the stacks equipped with the soft centre roll, or by lowering the lowermost roll in the uppermost stack in contact with the stack therebelow a stack of four hard rolls is attained, and the web is passed through the three nips of the stack.

Further, a soft calender known by the name OPTIGLOSS™ comprises two separate roll assemblies of three rolls, in both of which the middle roll is a hard thermo roll, and on both sides of the same there is a soft-faced roll. Thus, a calender with the total number of six rolls and four nips is attained.

As was described above, it is typical for all calender structures that the nips are opened by means of loading arms or loading levers, or by displacing other supporting structures that support the calender roll, for example a carriage supporting the roll, along guides which are parallel to the stack of rolls. This has been a prerequisite for being able to open the nips when the calendering method, i.e. the number or position of the calendering nips, is changed for example when the paper grade to be produced is changed. Similarly, prior art solutions such as EP-890676 are characterized in that the calendering method is changed by opening some of the nips and passing the web via the remaining closed nips. This results in that many rolls have to be displaced.

Further, problems associated with lever-loaded calenders, where hydraulic cylinders apply the required force, include the inaccuracy of loading when linear loads are small, due to *inter alia* friction of the hydraulic cylinders and pivotal joints. With large machine widths there are difficulties in obtaining a sufficient level of load by means of hydraulic cylinders acting through levers at both roll ends.

Further, due to the articulated suspension of the rolls on the frame, the construction is prone to vibrations at high machine speeds.

It is an aim of the invention to introduce a calender, which has a simple and reliable construction. To attain this purpose, the calender according to the invention is primarily characterized in what will be presented in the characterizing part of the appended claim 1.

At least some of the rolls in the calender stack are supported in a fixed position on the calender frame, and the roll shells are radially movable

to effect the loading and to open and close the nips. Problems associated with levers or arms can be avoided. According to one preferred embodiment, the calender contains two superimposed stacks of three rolls, in which the rolls can be transferred in such a manner that one running nip is attained between the two rolls right in the middle, or two running nips are provided in both stacks.

The calender contains preferably two stacks of three rolls. Both stacks of three rolls in the same calender frame advantageously contain a thermo roll in the middle, and a soft-faced roll above and below the same. The soft-faced rolls are movable-shell rolls, wherein they can be displaced in the direction of the nip plane by moving the shells in the radial direction. At least these movable-shell rolls are mounted in a fixed position on the frame of the calender, and the nip with the middle roll (thermo roll) can be opened and closed by movement of the roll shell. Thus, if the three-roll stacks are positioned one immediately above the other, by displacing the shells the lower movable-shell roll in the upper stack of rolls, and the upper movable-shell roll in the lower stack of rolls can be moved in nip contact with each other and off the nip contact with the middle roll in the upper stack of rolls and the middle roll in the lower stack of rolls, respectively. Similarly, the uppermost roll in the upper stack of rolls and the lowermost roll in the lower stack of rolls can be shifted away from the contact with the middle roll and back in nip contact with the middle roll by means of the motion of the roll shell in the direction of the nip plane. The rolls are mounted in a fixed position on the frame in such distances from each other that by means of the movements of the movable-shell rolls it is possible to open all the nips.

The invention enables the modification of the calender by arranging only the middle rolls (the uppermost roll in the lower stack of rolls and the lowermost roll in the upper stack of rolls) in contact with each other and away from each other to a nip contact with the centre roll in the stack of their own. Thus, it is possible to implement for example symmetric calendering in four nips formed by a hard-faced roll and a soft-faced roll when the nip between the lower calender roll in the upper

stack and the upper calender roll in the lower stack is open, or matte calendering by passing the web through the closed nip between the lower roll in the upper stack and the upper roll in the lower stack. By dimensioning the distance between the axes of the rolls, the diameters of the roll shells and the displacement lengths of the roll shells in the radial direction, it is possible to implement the change only by transferring the roll shells, i.e. separate displacement devices that displace the entire roll are not necessary.

In the following, the invention will be described in more detail with reference to the appended drawings, in which

Fig. 1 shows a side-view of a calender with open nips,

Fig. 2 shows a calender in a first running situation,

Fig. 3 shows a calender in a second running situation,

Fig. 4 shows a calender according to another embodiment in a side-view, and

Fig. 5 shows a detail of the calender of Fig. 4 in a front view.

Fig. 1 shows a side-view of a calender according to the first embodiment of the invention. In the frame R of the calender six rolls are placed on top of each other, said rolls forming two stacks A and B of three rolls. In the upper stack of rolls A, the uppermost and the lowermost roll 1 and 3 have movable shells, which shells can be displaced in the radial direction in parallel to the nip plane extending through the rotation axes of the rolls. The roll shells of said rolls 1 and 3 have soft surfaces, and they are equipped for example with a polymer coating. Between the uppermost and lowermost roll 1, 3 there is a hard heated roll 2, i.e. a so-called thermo roll. The surface of this middle roll 2 can be for example a smooth metal surface.

The lower stack of rolls B, whose nip plane continues as an extension to the nip plane of the upper stack of rolls A, has similar rolls in the same order as the upper stack of rolls A, i.e. the middle roll is a heated hard thermo roll 5 and above and below the same there is a movable-shell roll 4 and 6, respectively.

The movable-shell rolls 1, 3, 4 and 6 are so-called SYM rolls, inside of which there are loading elements placed on a stationary shaft and distributed on different zones over the machine width, said loading elements applying force in the radial direction and enabling the transfer of the roll shell in the radial direction and especially in the direction of the nip plane to open and close the nip formed by the roll, and to load the roll in an adjustable manner.

In both stacks of rolls A, B, the movable-shell soft rolls 1, 3 and 4, 6 all have similar dimensions and structures, and the middle rolls 2 and 5 in both stacks of rolls A, B have similar dimensions and structures. Consequently, only two types of rolls have to be arranged as spare parts for the calender.

The movable-shell rolls 1, 3, 4 and 6 are fixed to the roll frame R by means of supports 9 placed in substantially fixed positions, said supports projecting from the vertical sections of the calender frame and carrying the stationary shaft of the roll at both ends. Although Fig. 1 shows horizontal bolts 8 for fixing the support 9 to the calender frame R, the fixing can also be arranged in other ways, so that the supports can be arranged in a fixed position on the frame. However, there can be a possibility of fine-adjustment of the vertical position of the movable-shell rolls using spacer elements that can be placed for example below the shaft between the shaft and the support 9 at both ends of the shaft. This spacer element can be placed for example under the bearing housing of the stationary shaft end. The fine-adjustment of the fixed position allows to compensate for variations in roll diameters, for example after treatment of the roll surface.

The middle rolls 2 and 5 in the stacks of rolls A, B can be fixed to the frame R by their bearing housings by means of articulated supports, and they can be hydraulically relieved according to the principles of known articulated roll assemblies by means of a hydraulic cylinder effective on both ends between the bearing housing and the frame. However, the middle rolls 2 and 5 can be mounted on stationary supports that in the normal operation are not movable with respect to the calender frame R.

The rolls are placed in two superimposed stacks A, B in such a manner that the movable-shell rolls 1, 3, 4 and 6 can be transferred away from the middle hard rolls 2 and 5, and the lowermost roll 3 in the upper stack of rolls and the uppermost roll 4 in the lower stack of rolls do not touch each other. Thus, all the nips N1, N2, N3, N4, N5 from top to bottom are open. Fig. 1 illustrates this situation. The mutual distance d of the roll shells in the nips can be several millimetres, for example under 10 mm.

Fig. 2 shows a first running situation, in which both nips N1, N2 and N4, N5 of both stacks of rolls A, B are closed, i.e. a calendering nip is formed on both sides of the heated thermo roll 2, 5 with the corresponding soft-faced roll 1, 3 and 4, 6. Thus, in the first running situation the web to be calendered is passed through a total of four nips, all of which are nips formed by the soft-faced roll and the hard-faced heated roll. Between the stacks of rolls the web travels through an open nip N3. Thus, the web is also calendered symmetrically, i.e. in the first stack of rolls, the first surface is positioned against the hard, hot-faced roll, and in the next stack, the opposite surface is positioned against the hard hot-faced roll. By adjusting the loading and/or temperature, it is also possible to treat the different sides in successive stacks of rolls A, B differently from each other.

Fig. 3 shows another running situation, in which the lowermost roll 3 in the upper stack of rolls A and the uppermost roll 4 of the lower stack of rolls B is shifted away from the middle roll 2 and 5 in the corresponding stack of rolls, i.e. they are transferred in contact with each other to

close the space between the stack of rolls, wherein a calendering nip N3 is formed which is bordered by a soft-faced roll on both sides. In this running method, the web to be calendered is passed only through this nip N3 to conduct matte calendering. In this running method, the rolls 3 and 4, the SYM rolls, are turned 180° in such a manner that the loading elements are positioned at the location of the calendering nip N3. If either roll or both of the rolls is equipped with two sets of loading elements located within a distance of 180° from each other, the roll does not have to be turned.

If the supports of the centre roll 5 of the lower stack B are movable and not stationary, the nip N3 can also be formed in such a manner that the lowermost roll 6 in the lower stack B and the centre roll 5 fixed to the frame by means of for example articulated supports is lowered down, wherein the nip N4 is released, and the lowermost roll 3 in the upper stack A is lowered down to form the nip N3.

Separate loading cylinders are not necessary in the calender, because the loading can be implemented by loading elements located inside the shells of the SYM rolls (the soft-faced rolls 1, 3, 4, 6).

The drawings also show take-out rolls 7 which are typical for the calender, by means of which the web W to be calendered can be taken out from the nips, said take-out rolls being placed on both sides of the stacks of rolls A, B.

The above-described calender is advantageously used for on-line calendering of paper, wherein the calender can be placed in the papermaking line. The calender is short in the machine direction, wherein it can be easily positioned in an old line for example in connection with modernizations. Furthermore, the grade change, i.e. the change in the running method from the calendering method of Fig. 2 to the calendering method of Fig. 3, and vice versa, can be easily implemented.

Fig. 4 shows a calender according to the invention in another configuration, where a symmetrical calendering of the paper web, corresponding to the running situation of Fig. 2 also is possible. Also in this case the calender rolls have fixed positions as far as the mounting of their supports 9 projecting out from the frame and their shafts is concerned. The calender is a 4-nip calender having two stacks A, B, each consisting of three calender rolls. The stacks are spaced from each other in the machine direction and form permanently separate stacks. In both stacks, the uppermost rolls 1 and 4, respectively, and the lowermost rolls 3 and 6, respectively, are movable-shell rolls having a soft face. These rolls, being for example so-called SYM rolls, work on the same principle as in the calender of Figs 1 to 3, that is, the radial loading and displacement of the roll shell to form a nip contact and to open and close the nip with the centre roll takes place by internal loading elements distributed in the cross-direction of the calender and supported on the stationary roll shaft. The centre rolls 2 and 5 in the stacks A, B, respectively, are heatable hard-faced thermo rolls, as in the embodiment of Figs. 1 to 3. The supports of said thermo rolls are attached to the frame in fixed positions.

The uppermost and lowermost rolls 1, 3, 4, 6 in both successive stacks A and B are variable-crown rolls by virtue of the internal loading elements disposed in different axial positions over the length of the roll shell. By means of these variable crown rolls it is possible to apply both large and small linear loads with a good profiling accuracy without an adverse effect on the size of the calender frame, compared with calenders equipped with loading levers. The vibrations can also be better controlled.

The passage of the paper web W to be calendered is that used in conventional lever-loaded calenders having two stacks of three rolls. The web W enters the first nip N1 between the lowermost roll 3 and the centre roll 2 in the first stack A after having passed over a spreader roll 10. Thereafter the web travels over a take-out roll 7 and a spreader roll 10 and enters the second nip N2 between the centre roll 2 and the uppermost roll 1, and thereafter it is guided by the guide rolls 11 above

the stacks to the other side of the second stack B onto a spreader roll 10 and to the third nip N3 between the uppermost roll 4 and the centre roll 5 of the second stack B, after the nip N3 over take-out rolls 7 and a spreader roll to the last, fourth nip N4 between the centre roll 5 and the lowermost roll 6 of the second stack B.

To facilitate the roll change, the nip planes defined by the uppermost rolls 1, 4 and the centre roll 2, 5 in both stacks are A, B, respectively, are vertical and the nip plane defined by the centre rolls 2, 5, and the lowermost rolls 3, 6 in both stacks A, B, respectively, are inclined to an angle of about 15° in such a manner that the lowermost rolls 3 and 6 are situated towards the open side of the calender frame from the vertical centre line of the corresponding centre roll 2 or 5. The nip plane of two rolls means the plane common to the rotational axes of the rolls.

The uppermost rolls can be changed with a minimum movement of the roll shell to open the nip they form with the respective centre rolls below. Thereafter the roll can be moved in the horizontal direction to the open side of the calender frame (sideways to the left from the stack A and to the right to the stack B as seen in Fig. 4).

To compensate for the variations in the diameters of the movable-shell uppermost rolls 1, 4 and the movable-shell lowermost rolls 3, 6, spacer elements 12 are disposed between the roll supports 9 and the calender frame R, this spacer element 12 adjusting the position of the roll support and stationary roll shaft carried by the support 9 with respect to the rest of the calender construction. These spacer elements 12 are interchangeable and exist in different thicknesses.

Because of short movements associated with the movable-shell rolls in opening the nips, special care must be taken when changing a roll after it has been detached from a nip contact. Fig. 5 shows a construction in a front view that makes possible the change of the uppermost roll of the stack. The spacer element 12 and the roll support 9 can be fixed to each other and to the frame by fixing means not shown. The roll support 9, depending down from a horizontal portion of the calender

frame R, is fixed to the calender frame so that the aforementioned spacer element remains interposed between the calender frame and the support. The other roll support on the opposite end of the roll has a similar construction and mounting on the frame. The spacer element 12 is provided with a profile 13 that fits inside a corresponding groove 14 in the calender frame. The profile and the groove together form a horizontal guide extending in the machine direction. The profile and groove can have complementary cross-sectional shapes, in the case shown the shapes of a T. By means of suitable tools or actuators the uppermost roll together with its support 9 and the spacer element 12 can be shifted in the machine direction directly away from the calender frame and from the position above the centre roll in a linear horizontal movement guided by said guide, without the use of positioning wedges. The same construction to effect the change can be used also for the lowermost rolls 3, 6 of the stacks A and B.

Placement of the uppermost rolls to form a vertical nip plane for easier roll change of the movable-shell upper roll does not cause problems of zero load of the bearings, if the movable-shell rolls 1, 3, 4, 6 use sliding bearings at the shell ends for the rotational movement of the shell. The inclination by about 15º of the lower nip plane (between the centre thermo roll and the lower roll) allows an easy roll change of the lower movable-shell roll 3, 6, and this position is also advantageous for the possible zero load of the roller bearings of the centre thermo roll 2, 5.

Claims:

1. A multi-nip calender with soft-face and hard-faced rolls positioned on top of each other to form a stack, **characterized** in that at least two rolls (1, 3; 4,6) forming each a nip with a centre roll (2; 5) between said two rolls are mounted in a fixed position on the frame (R) of the calender in such a manner that their shells can be moved in the direction of the stack of rolls with respect to the supports (9) of the rolls.

2. The calender according to claim 1, **characterized** in that one of the two rolls (1, 3; 4, 6) is an upper roll (1; 4) and the other one is a lower roll (3; 6) in a stack of three rolls (A, B) that permanently or provisionally forms a separate stack of rolls in the calender frame (R).

3. The calender according to claim 2, **characterized** in that the upper roll (1; 4) and the lower roll (3; 6) are soft-faced rolls.

4. The calender according to claim 3, **characterized** in that the centre roll (2; 5) in the stack of rolls (A, B) is a hard roll.

5. The calender according to claim 4, **characterized** in that the centre roll (2; 5) is a heated thermo roll.

6. The calender according to claim 2, 3, 4 or 5, **characterized** in that the calender includes two stacks (A, B) of three rolls which each form permanently or provisionally a separate stack in the calender frame (R).

7. The calender according to claim 6, **characterized** in that the upper rolls (1; 4) and the lower rolls (3; 6) in both stacks of three rolls (A, B) are soft-faced rolls.

8. The calender according to claim 7, **characterized** in that the centre rolls (2; 5) in both stacks of three rolls (A, B) are hard rolls.

9. The calender according to claim 8, **characterized** in that the centre rolls (2; 5) in both stacks of three rolls (A, B) are heated thermo rolls.

10. The calender according to claim 2, **characterized** in that it includes two stacks (A, B) of three rolls positioned on top of each other in such a manner that at least the lower roll (3) in the upper stack of rolls (A) and the upper roll (4) in the lower stack of rolls (B) can be detached from the contact with the rolls (2, 5) in the stack of rolls (A, B) of their own and moved into nip contact (N3) with each other.

11. The calender according to any of the preceding claims, **characterized** in that said two rolls (1, 3; 4, 6) are equipped with loading elements inside the roll shell.

12. The calender according to any of the preceding claims, **characterized** in that at least one of said two rolls (1, 3; 4, 6) is mounted on the calender frame (R) by supports (9) whose connections to the frame comprises guides (13, 14) allowing the roll change guided by said guides.

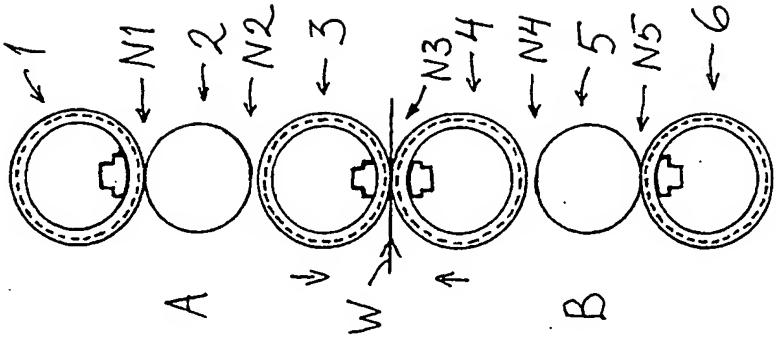

Fig. 3

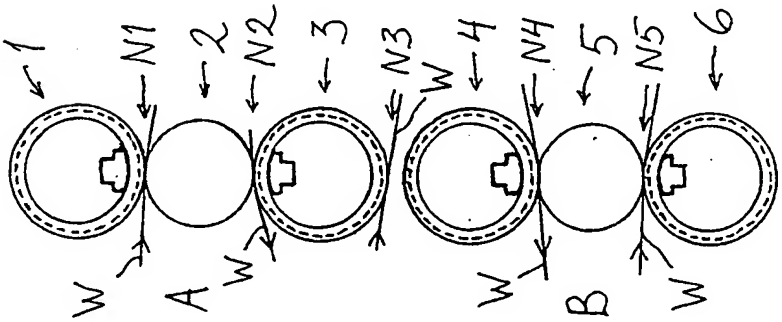

Fig. 2

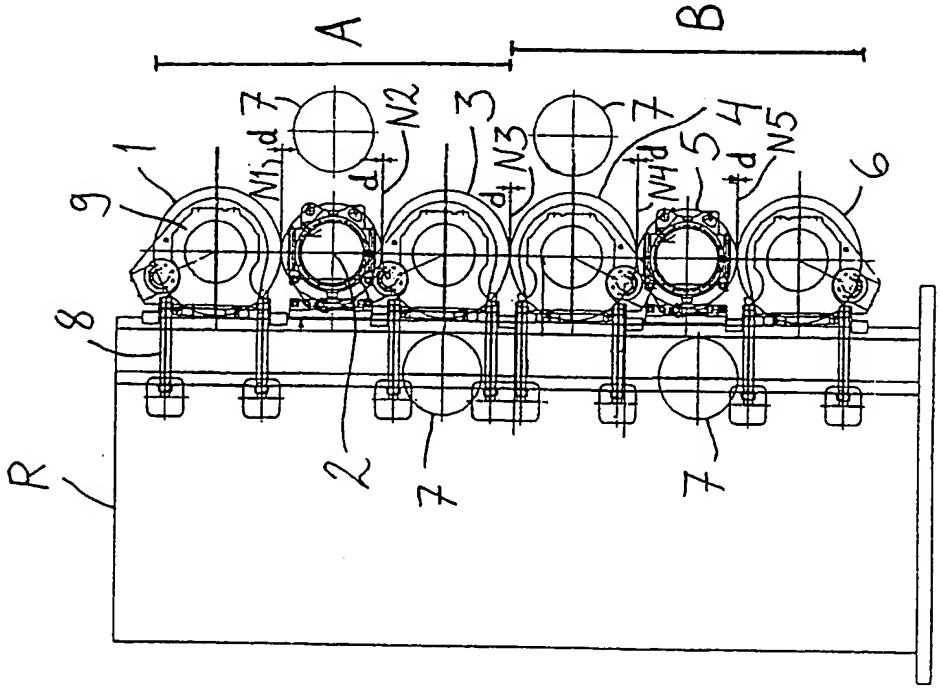

Fig. 1

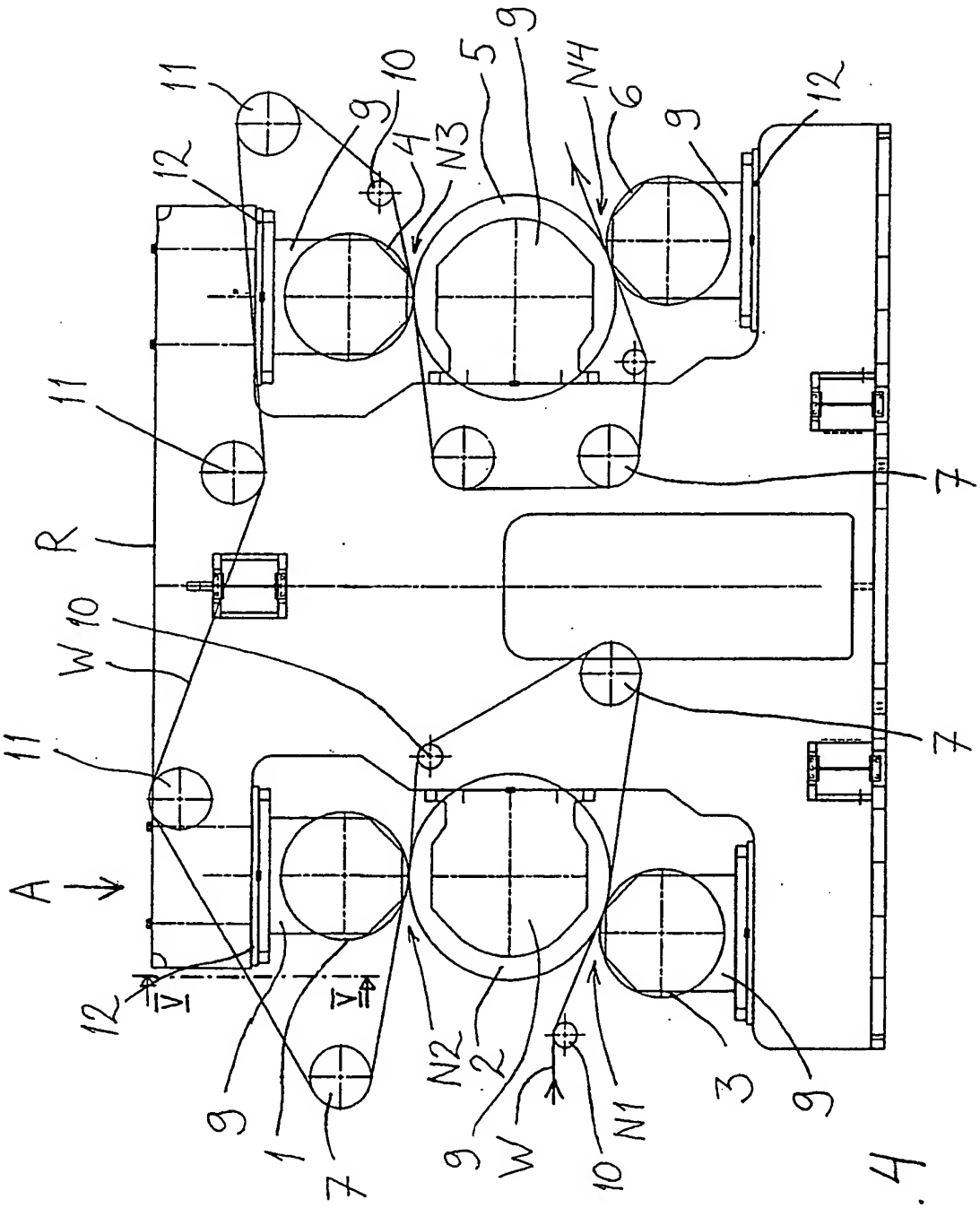

Fig. 4

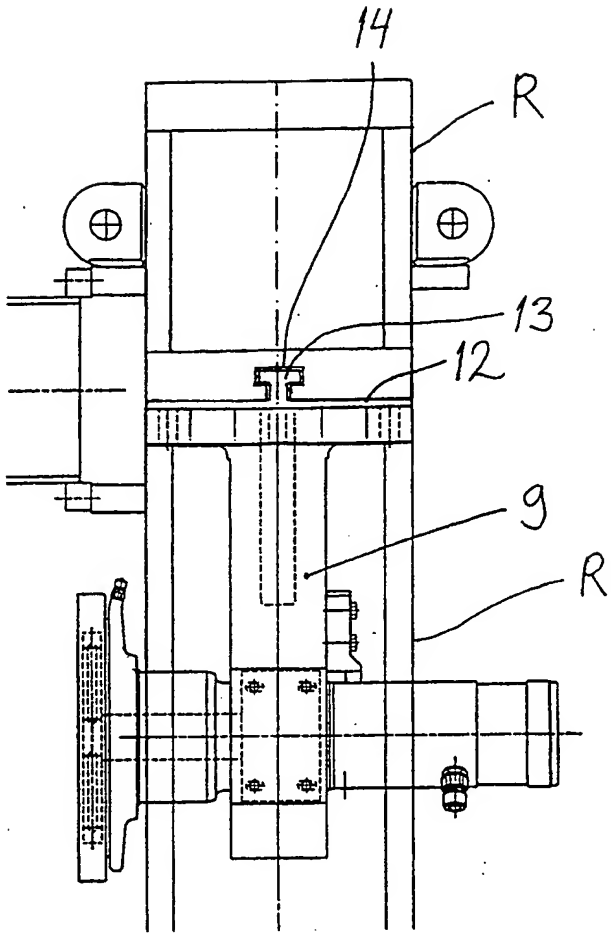

Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/F 01/00180

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 D21G1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 D21G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 972 877 A (VOITH SULZER PAPIERTECHNIK PATENT GMBH) 19 January 2000 (2000-01-19) column 2, line 39 - line 57 ---	1-12
X	RUDI MINKENBERG AND PETER URBAN: "a new role for on-machine calender stacks" TAPPI JOURNAL, vol. 69, no. 12, 1 December 1986 (1986-12-01), pages 39-44, XP002059207 norcross,ga,usa the whole document ---	1-5
A	EP 0 822 289 A (VOITH SULZER FINISHING GMBH) 4 February 1998 (1998-02-04) the whole document --- -/--	1,2,6, 10,11

[X] Further documents are listed in the continuation of box C.

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International Application No
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